Research and Production

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THERE seems to be no question that economic production of proper quality is the basis of prosperity in any industry. Quantity production frequently makes possible the domination of a market and in the past has been possible without the extensive application of research, principally because raw materials have been sufficiently abundant, labor has been comparatively inexpensive, and in many fields competition has been restricted because of undeveloped transportation facilities. This time in general has passed, and even in those industries where raw material is still abundant it is found necessary to engage in research if for no other reason than to guarantee supplies for the future.

Research Defined

The term "research" is applied to the effort made in new, original directions to solve problems by the application of science and the scientific method. It involves learning what has gone before and is almost always preceded by a careful search of literature. It may be undertaken either to solve some problem in pure science, something with reference to commercial application or, in industrial research, it may mean the application of all the information that has been secured to the solution of an industrial problem. This may concern raw materials, processes, the utilization of wastes or the improvement of products. At times it may take the form of an order for an invention when the research laboratory endeavors to produce something entirely new for a given purpose. Research, then, no matter what may give rise to it, is sure in the long run to benefit industry and react advantageously upon production. This, in turn, directly benefits the producer in every part of an industrial organization. The success of research in this field can best be illustrated by a number of examples chosen to emphasize particular phases.

Research in Illumination

The influence of proper lighting conditions upon the health, comfort and productive capacity of the workmen is well recognized. These facts have been established by research and these conditions have been improved in proportion to the knowledge we have gained by careful inquiry into the laws and principles of light and illumination. The mercury vapor lamp, such as the Cooper-Hewitt, a result of scientific endeavor, is well adapted to illumination for some types of work. More commonly, types of incandescent or arc lamps are employed, and one of our most fascinating stories of research centers around the production of these modern lighting units. We can recall the days of the comparatively dim carbon lamp. A little later the Tantalum filament was introduced, followed by tungsten, but these filaments were fragile and the lamps were short-lived. Behind it all there was the most intense competitive research going on in Germany and America for it was realized that to make these more efficient lamps commercially possible a way must be found

to draw tungsten into fine wire. Owing to the characteristics of the element this seemed an almost impossible feat, but in the end American research won and ductile tungsten has become an article of commerce. Through this step America won the incandescent lamp industry which has since been more firmly established through researches begun in pure science on the conductivity of gases. We now have incandescent lamps filled with inert gas, and the use of the vacuum with the carbon filament is rapidly disappearing.

Today, a manufacturing establishment can be much better lighted, the illumination better controlled and the worker given these advantages at far less cost than would otherwise have been possible. We are told that if we were all using the old-type carbon filament today the annual electric lighting bill of the nation would be at least four hundred million dollars greater than it is now. Research, therefore, has provided lighting units to enable the maintenance of production under otherwise unfavorable light conditions without detriment to the workmen. Few things interfere with normal and increased production more than poor illumination. Modern science makes it comparatively simple to overcome this defect.

RESEARCH SHORTENS PROCESSES

"Speeding up" is a familiar phrase in industry and can only be realized with the help of scientific research. In the rubber industry vulcanization is a necessary step which in the past required at least two hours. We are using increasing quantities of rubber products and items of equipment are very important, requiring as they do great outlays of capital upon which dividends must be paid. If, then, research can make it possible to turn out a greater number of tires per day with the same equipment and the same amount of labor, surely the condition has been so improved that both labor and capital profit. This has been accomplished by the use of organic accelerators of vulcanization. These are amino derivatives, now recognized as catalysts which assist in carrying the sulphur to the rubber molecule. A rubber mixture containing such an organic accelerator can be properly vulcanized in thirty minutes instead of the two hours formerly found necessary. A manufacturer, therefore, can vulcanize three or four times as many tires with the same equipment as formerly.

The modern tool steel is another example of what research has done in increasing production. The new alloy steels in which some of the unusual elements are combined with the iron are capable of retaining their metal-cutting properties at much higher temperatures than the older type of high-carbon steels. This means that a lathe can be operated much faster without spoiling the tool, and a plant which has been using carbon steel can accomplish nearly three times as much work if the modern tool steels are substituted. Those engaged in research on tool steels believe that an even better record can be made, and during the war a new alloy of tungsten, cobalt and chromium proved to be even more efficient than the somewhat older types of alloy steels.

In connection with metal cutting, it should also be noted that production has been improved through researches upon lubrication and the various cooling and cutting compounds which make continuous work possible. Another step has been taken in providing ways for recovering these oils and lubricants from the metal chips, at the same time so clarifying it that it can be re-used with safety and economy.

Another example can be drawn from the textile industry. At one time our only means of bleaching was the tedious process of spreading cloth upon the grass, where it remained in sunshine for days. Later came chemical methods which at first were uncontrolled and their reactions little understood. Research found in one case that the reaction which was believed to require thirty hours could be made to go forward efficiently in forty-five seconds under proper temperature and pressure control. This meant that only one-fifteenth of the capital was required for apparatus, raw materials and investment in goods in process.

Not only can production be increased in gross volume but the net output is affected through the scientific control of raw materials. Science enables us to choose with considerable accuracy the raw materials which are suited to a given operation, and this means fewer rejections and imperfect parts, all of which has a direct bearing upon the economy of production. There was an instance where a hardened steel part was made for army equipment. The material had to be formed and hardened afterward. One of the manufacturers, finally realizing that it was a scientific problem, had a piece of research done upon the process after it had been demonstrated that his usual method of working resulted in a very high percentage of rejections. In a short time a metallurgist found the difficulty and was able so to modify the process that from that time on there were practically no rejections and the plant in question was able to get by far the largest share of orders for that particular device. Obviously, production that results in unsatisfactory merchandise is a failure, and in so far as research can assist in avoiding such failures it unquestionably has an important bearing upon production.

Research also affects the economy of production, enabling materials to be made at a price which guarantees a great demand, and thereby directly benefits both labor and capital. An example is the use of vanadium steel for certain parts of automobiles. The work which these parts are called upon to perform necessitates the use of a steel such as high-carbon steel, which is very difficult to machine. Vanadium steel meets the specifications and has the advantage that it is easily machined, so that the part can be supplied at approximately one-half the cost which would be necessary but for the alloy steel which research has given us.

WASTES PUT TO WORK

Many examples of this type could be cited, but the influence of research upon the economy of production cannot be passed without referring to waste recovery and utilization. In the production of better grades of mirrors, metallic silver is precipitated upon the glass by means of a chemical process. Under ordinary conditions a very small per cent of the silver is deposited upon the glass, the majority being plated out on the containing vessel and deposited in it in the form of a "mud." The character of this mud was soon determined and methods devised for its recovery and re-use. More recently we have learned how to control the reactions so that a far greater quantity of the silver deposits where it is wanted, with the result that the whole operation, including waste recovery, is simplified and made less expensive.

In the wool industry, research has provided means for recovering values from the wash-waters which, during the war in the case of one large mill, produced a revenue sufficient to pay the dividends on its capital stock.

The recovery of this waste was a direct benefit to the community health, through the removal of a putrefiable waste from sewage, and a producer of profit for the mill in question.

One of the classical examples of waste recovery through the application of research is to be found in the cement industry, where the application of the Cottrell electrical precipitating method first made it possible to strip fumes and waste gases of the dust which otherwise settled with devastating effect upon surrounding vegetation. Later it was found that this dust contained most of the potash present in the raw materials entering into the cement, and in at least one case the mill could be operated entirely upon the proceeds from the sale of the recovered potash, making the proceeds from the sale of the cement clear profit.

INCREASING YIELDS

The incease in yield from a given operation is another instance of what applied science can accomplish. Such increases follow a close study, from a scientific standpoint, of the factors which underlie the reaction. These include time, temperature, pressure and concentration. True, it frequently occurs that a process is developed without the aid of science and finds its optimum conditions for working to lie within certain narrow limits, but until we know why we carry on a process in a given way, as well as how to proceed with the work, we cannot expect the best results. Research learns the "why," and when employed in advance eliminates the many costly errors that always follow rule-of-thumb methods. Knowing the underlying principles of a reaction, the scientist can calculate very closely what should be done to produce a maximum yield, thus greatly lessening the amount of time necessary for experiment. There is an example in the dye industry where a yield of but 10 per cent was increased to 95 per cent by merely prolonging a stirring operation five minutes at one point in the process.

In our greatest industry—agriculture—we find many illustrations of increased production due to the application of research. In Connecticut a close study of the tobacco plant resulted in learning how to secure two or three times the number of leaves suitable for wrappers with the same expenditure of energy in cultivation. On the Pacific Coast hybridization has produced a walnut tree that grows with the rapidity of the poplar and begins to yield years in advance of the time that would otherwise be possible. Applied to wheat, scientific research for new varieties has already introduced into our country types which have added millions to the value of the wheat crop and benefited capital and labor alike from the farmer through the chain, including elevators, millers, exporters and wheat products manufacturers, to the consumer.

Turning now to the electric field, consider the production that has been made possible by spot welding, arc welding, and the utilization of the electric furnace. The influence upon industry in general of electrochemical and electrometallurgical products constitutes one of our most important industrial chapters. Upon the achievements of research in these fields depends the present efficiency of some of our greatest industries. Thus ferro silicon, an electric furnace product, is a necessity in the production of open-hearth steel, which constitutes something like 70 per cent of our total tonnage. Researches in the field of the electric furnace and its application have given us much of our alloy steels, to which reference has already been made. It has also made it possible to utilize scrap and even foundry sweep-

ings in a way which has heretofore entailed much more expense and time. Those who have occasion to do metal cutting and brazing also have reason to appreciate research, which has given us large supplies of oxygen and hydrogen at commercial figures and has made acetylene an article of commerce.

RESEARCH IN THE HUMANITIES

Scientific research on the human factors in production is in its infancy. But the problems are now well defined, and the technique for studying them is being rapidly improved. In certain large industries as diverse as textiles, automobiles, meat-packing, paper, rubber and electrical equipment, essentially the same types of systematic records and statistical analysis of industrial personnel data have been found helpful in locating unsuspected causes of dissatisfaction and unrest, and in pointing the way to necessary changes in working conditions and in methods of supervision, training, placement, promotion and wage adjustment. Improved analyses of jobs and the requirements they make of the workers have been coupled with more intelligent attention to the individual workers, their varying abilities, aptitudes and ambitions; and the systematic effort to adapt the jobs to the workers, as well as to equip the workers for their jobs, has increased the satisfaction of the employees while increasing their earning power and their wages.

SAFETY IN INDUSTRY

Safety for the worker has not been overlooked by research. Perhaps one of the best examples may be drawn from the match industry, where "phossy jaw" was a terrible possibility for all those engaged in the preparation and handling of match-head mixtures. The red phosphorus used was somewhat less toxic than the other form of the element, namely "white phosphorus," but after a considerable series of researches it was found that phosphorus pentasulphide was the compound which could be substituted with satisfaction so far as the final product was concerned and with complete safety to the workers. This was really a wonderful achievement and the patented results were later assigned to the public, the company originating the process believing that while it gave them an insurmountable advantage over competitors the process was so closely identified with preservation of the health of match workers that it would be far better to allow any who cared to use this result of research to do so.

In the vulcanization of rubber, to which reference has been made, there were certain dangers accompanying the use of the first accelerator suggested, but these dangers have been greatly minimized by the employment of more recently developed compounds and by the re-designing of the mixing apparatus in which the materials are incorporated. Another notable example of the efforts of research to protect labor is found in the researches of Sir William Crooks who developed a glass to be used in goggles that affords almost complete protection against ultra-violet light, and another type which likewise protects the wearer from the infra-red or heat rays. The ideal would be to combine this ability to protect the eyes in one type of glass, but so far this has not been possible with the necessary degree of visibility. Another important part of the goggle has been made safe by the substitution of cellulose acetate for the nitrate, the former being non-inflammable or slowly burning. Celluloid continues to be a subject of research and some progress has been made in rendering it less inflammable, thereby directly af-

fording increased protection to those obliged to work with this material.

LABOR'S INTEREST IN RESEARCH

Labor, therefore, no less than capital, is interested in the relation between research and production. This interest comes not only because of the immediate concern of workers engaged in a particular process, but also because they in turn desire to have available for their own use the many products which modern science makes possible. This includes most of the things now looked upon as necessities as well as those which are admittedly luxuries. Most of these materials must be produced economically and in quantity if they are to be available at a price within the reach of the majority. Such production is not possible without the application of scientific method and the utilization of all that research has to offer or can provide. An industry founded upon a science, such as the electrical and the dye industries, in most respects is advanced beyond those industries which fail to recognize the fact that they are in many instances carrying on processes involving reactions which cannot be fully understood without the aid of science. These resolutions adopted in 1919 at the Atlantic City Meeting of the American Federation of Labor indicate clearly that labor is coming to appreciate the significance of research:

"WHEREAS, Scientific research and the technical application of results of research form a fundamental basis upon which the development of our industries, manufacturing, agriculture, mining, and others must rest; and

"WHEREAS, The productivity of industry is greatly increased by the technical application of the results of scientific research in physics, chemistry, biology, and geology, in engineering and agriculture, and in the related sciences; and the health and well-being not only of the workers but of the whole population as well, are dependent upon advances in medicine and sanitation; so that the value of scientific advancement to the welfare of the nation is many times greater than the cost of the necessary research; and

"WHEREAS, The increased productivity of industry resulting from scientific research is a most potent factor in the ever-increasing struggle of the workers to raise their standards of living, and the importance of this factor must steadily increase since there is a limit beyond which the average standard of living of the whole population cannot progress by the usual methods of readjustment, which limit can only be raised by research and the utilization of the results of research in industry; and

"WHEREAS, There are numerous important and pressing problems of administration and regulation now faced by federal, state and local governments, the wise solution of which depends upon scientific and technical research; and

"WHEREAS, The war has brought home to all the nations engaged in it the overwhelming importance of science and technology to national welfare, whether in war or in peace, and not only is private initiative attempting to organize far-reaching research in these fields on a national scale, but in several countries governmental participation and support of such undertakings are already active; therefore, be it

"*Resolved*, By the American Federation of Labor in convention assembled, that a broad program of scientific and technical research is of major importance to the national welfare and should be fostered in every way by the Federal Government, and that the activities of the government itself in such research should be adequately and generously supported in order that the work may be greatly strengthened and extended; and the Secretary of the Federation is instructed to transmit copies of this resolution to the President of the United States, to the President pro tempore of the Senate, and to the Speaker of the House of Representatives."

Capital also has a better appreciation of what science means than was the case but a short time ago. If capital and labor will join in the employment of science for the solution of their mutual production problems, there can be no question as to the ability of American industrial organizations to maintain and improve their place in world commerce.